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Bell's Outdoor and Indoor Experimental Arithmetics

Fifth Year's Course
(Standard VII)

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Outdoor and Indoor Experimental Arithmetics

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FIFTH YEAR'S COURSE (Standard VII.)

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FOREWORD.

THE aim of this series is to lead children—by experiment, inference, comparison and contrast—to form a real conception of Length, Area, Weight and Volume.

Each experiment has a definite end in view; either the establishment of an abstract principle, or the practical proof of a theoretical calculation.

The exercises are intended to be taken at times specially set apart for practical work, as it is generally found to be inconvenient to combine practical and theoretical exercises in the same lesson.

They provide, moreover, an interesting and ample course of hand and eye training, which, preceding the theory lessons, it should, has the effect of stimulating the child's activities and associating in his mind the world of things with the world of ideas.

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OUTDOOR AND INDOOR EXPERIMENTAL ARITHMETIC.

FIFTH YEAR'S COURSE.

SECTION I.—LENGTH.

1. The Principle of Similar Triangles.

(a) Construct a right-angled triangle ABC , having two of its sides 8" and 9" respectively (Fig. 1).

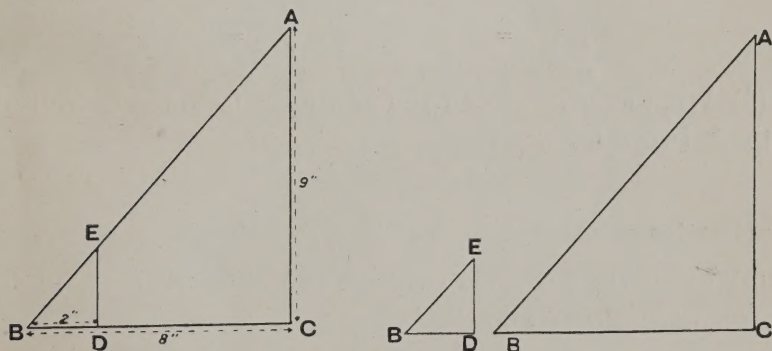


FIG. 1.

- (b) From B mark off BD 2" long.
(c) Through D draw DE parallel to CA to meet BA in E .

(d) Carefully examine the angles of the triangles BED and BAC .

(i) By means of your protractor compare the angles BDE and BCA .

(ii) In the same way compare the angles BED and BAC .

(iii) Compare also the angle EBD with ABC .

(e) What statement can you now make with regard to corresponding angles of the two triangles ?

(f) Complete the following statements, after using your ruler, if necessary :

(i) Length of BC =

(iii) Length of BD =

(ii) „ CA =

(iv) „ DE =

(g) From the measurements you have just made, complete the following statements, so as to make ratios of equality :

$$(i) \frac{BD}{DE} =$$

$$(ii) \frac{BC}{CA} =$$

(h) What conclusion can you now draw from the magnitude of these two ratios ?

2. Application of the Principle of Similar Triangles.

(a) From the previous exercise you obtained that, in the two triangles BED and BAC ,

$$\frac{BD}{DE} = \frac{BC}{CA},$$

or

$$BD : DE :: BC : CA.$$

(b) For each of these parts, substitute its actual length.

- (c) Find the product of the *extreme* terms (BD and CA).
 (d) „ „ „ *mean* terms (DE and BC).
 (e) Comparing these two products, what conclusion can you draw ?
 (f) From the above, if $BD \times CA = DE \times BC$, write down, in terms of the others, the value of

- (i) BD , e.g. $BD = \frac{DE \times BC}{CA}$,
 (ii) CA . (iii) DE . (iv) BC .

3. Finding Height of First-Floor Window.—Use of Theodolite.

I. Taking Measurements.

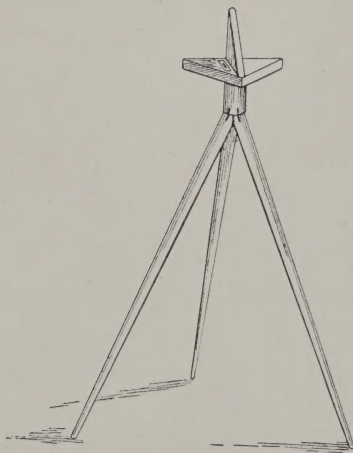


FIG. 2.—SIMPLE THEODOLITE.

- (a) From a point on the playground vertically below a first-floor window, mark a chalk-line on the playground at right angles to the wall.

(b) Place your eye at position *A* (Fig. 3) and look along the edge of the theodolite, noticing where the line of sight meets the school wall.

(c) Move the theodolite backwards or forwards (as the case may be) along the chalk-line, until a position is found where the line of sight just touches the *bottom* of the window.

(d) By means of the plumb-line find, on the chalk-line, the point *X*, vertically below *A*.

(e) Measure the distance *AX*, *i.e.* the height of the theodolite.

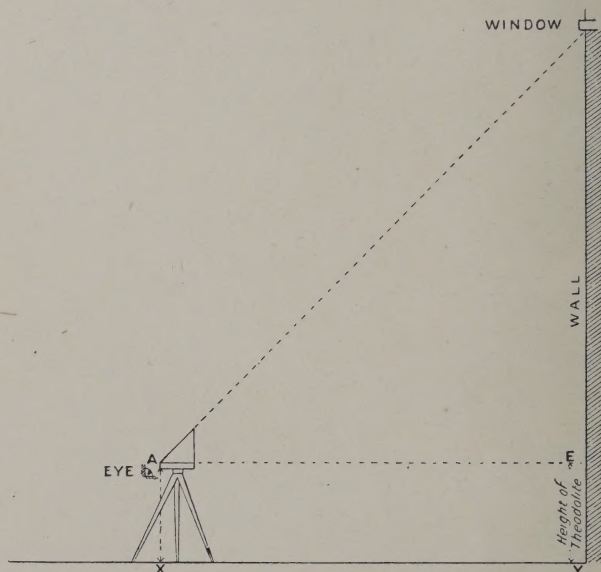


FIG. 3.

(f) Carefully measure the distance *XY*, that is, from the theodolite to the wall.

Enter your result.

(g) Measure also (inches and tenths) the sides of the triangular portion of the theodolite.

Enter these measurements.

II. Drawing to Scale.

(a) Taking any convenient scale, make a drawing shewing similar triangles (Fig. 4).

Measurements known.

- (i) Base of theodolite triangle, *i.e.* BD .
- (ii) Height of theodolite triangle, *i.e.* DE .
- (iii) Base of large triangle, *i.e.* BC .

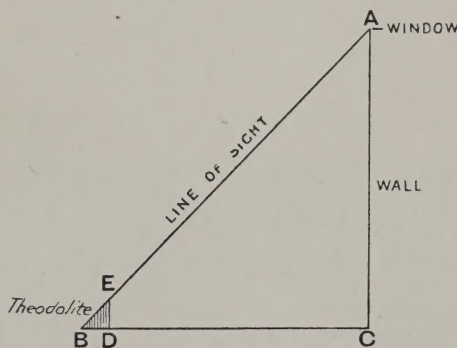


FIG. 4.

(b) Now measure AC , the height of the large triangle.

(c) By reference to the scale, find its actual length.

(d) To this add the height of the theodolite from the ground, and enter the same in your note-book.

III. Calculation.

(a) Make equality of ratio between two of the sides of the theodolite triangle and the corresponding sides of the large triangle, thus :

$$\frac{BD}{DE} = \frac{BC}{CA} \quad (\text{Fig. 5}).$$

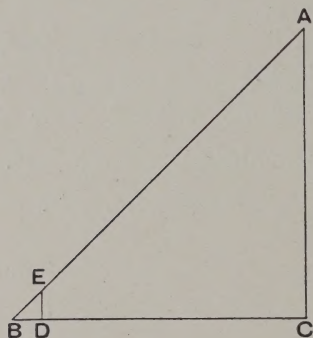


FIG. 5.

(b) Apply the method of Ex. 2, and by calculation find AC , and so obtain the actual height of the window.

(c) To this add the height of the theodolite from the ground.

(d) Compare your result with that obtained by drawing to scale.

IV. Verification.

(a) Working from the window, and using the long tape measure, find the *real height* of the window from the play-ground.

(b) Compare this result with the preceding ones, and then tabulate them thus :

HEIGHT OBTAINED BY		
II. Drawing to Scale.	III. Calculation.	IV. Actual Measurement.

4. Finding Height of Inaccessible Objects.

By means of the theodolite and

(a) method of drawing to scale,

(b) „ calculation,

determine the heights of :

(i) Tall tree.

(iii) Flag-post.

(ii) The school.

(iv) Factory chimney.

5. Slant Height.

NOTE.—*This exercise should not be worked until Ex. 24 has been completed.*

(a) Measure the height of the gutter of your school roof with the theodolite.

(b) From the wall mark off a distance of 6 ft.

(c) By using the formula obtained in Ex. 24, find the length of ladder required to reach the gutter.

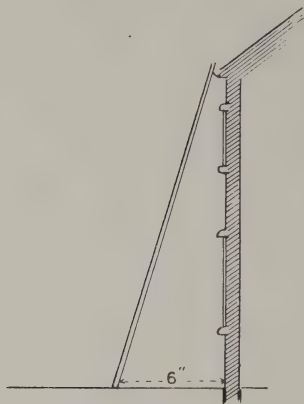


FIG. 6.

(*d*) Make a drawing to scale, as in Fig. 6, and measure the hypotenuse.

(*e*) Compare results (*c*) and (*d*).

6. Another Form of the Principle of Similar Triangles.

(*a*) Draw a line AB 6" long and bisect it at O (Fig. 7).

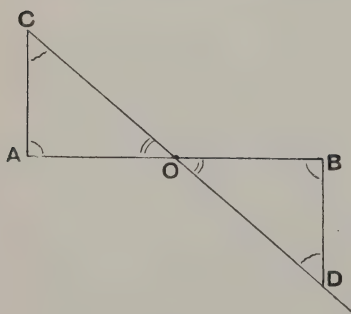


FIG. 7.

(*b*) At A draw a line AC at right angles to AB and make AC $2\frac{1}{2}$ " long.

(*c*) Join CO and continue the line.

(*d*) From B draw BD at right angles to AB to meet CO produced in D .

(e) Work the following exercises :

- (i) Compare the angle CAO with the angle OBD .
- (ii) " " AOC " " BOD .
- (iii) " " ACO " " ODB .
- (iv) What is the nature of the triangles CAO and OBD ?
- (v) Which side in the triangle OBD is the same length as AO ?
- (vi) Which side in the triangle OBD is the same length as OC ?
- (vii) Which side in the triangle OBD is the same length as AC ?

Write down the length in this case.

7. Finding Width of Stream or River. (Method I.)

(a) Take some prominent object, C , on the opposite bank (Fig. 8).

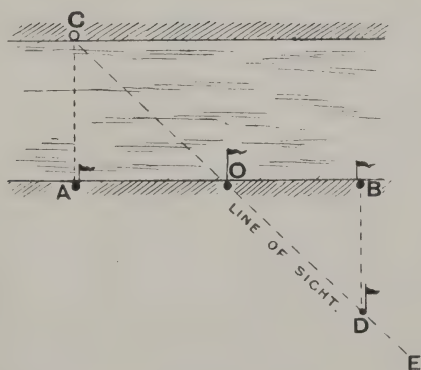


FIG. 8.

(b) By means of the cross-staff, find a point A so that the imaginary line CA makes a right angle with the bank.

(c) Insert an arrow or pole at A .

(d) From A measure off a convenient distance (say 10 yards) and set up another mark at O .

(e) Sight CO , and continue the line of sight in the direction of E , as shewn in diagram.

(f) Lay the chain on the ground immediately below the line of sight, so as to mark its direction accurately.

(g) From O mark off OB equal to OA .

(h) At B make a right angle by using the cross-staff, and so find the point D .

(i) Measure the length of BD .

(j) To what line in the triangle ACO is it equal?

(k) Write down the width of the stream.

8. Finding Width of Stream or River. (Method II.)

(a) With the chain, mark off a convenient distance AB , setting up poles or flags at A and B . (Fig. 9)

(b) Find a prominent object C on the opposite bank, so that it lies between A and B .

(c) By means of the theodolite or anglemeter, carefully measure the angles CAB and CBA .

Record your results.

(d) Now find a point D , so that CD is at right angles to AB .

(e) Measure the distance DE , that is from the base line AB to the water's edge.

(f) From the measurements made, draw the triangle to scale, and find the length of the perpendicular CD .

(g) Knowing the length of CD and also of DE , calculate the width of the stream.

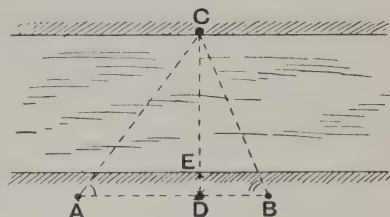


FIG. 9.

9. Scale shewing Inches and Tenths.

(a) Draw a line AB and mark off inches along it (Fig. 10).

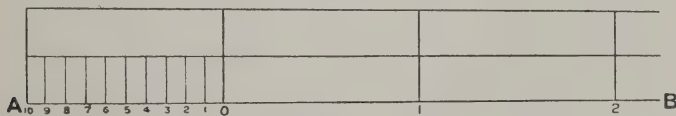


FIG. 10.

(b) Through A , 0, 1, 2, . . . draw perpendiculars to AB (about $\frac{1}{2}$ " in height), and complete as shewn above.

(c) Subdivide $A0$ into 10 equal parts and erect perpendiculars as indicated.

Take care to number the parts from 0.

(d) Draw a long straight line in your note-book.

(e) By means of compasses or dividers take off 1.7" from your scale, mark off the same on the line, and indicate its length.

(f) From the point just obtained in (e) mark off a further distance—2.3".

(g) What should be the total length marked off? Check your work.

(h) Draw another line, and proceeding similarly, mark off 3·6" and 0·8".

(i) Using the scale you have drawn, find the lengths of the lines in Fig. 11.

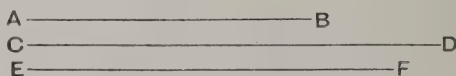


FIG. 11.

10. Diagonal Scale shewing Inches, Tenths, and Hundredths.

(a) Draw a straight line AB and mark it into inches, shewing the points of division, 0, 1, 2,

(b) At equal intervals draw 10 straight lines parallel to AB .

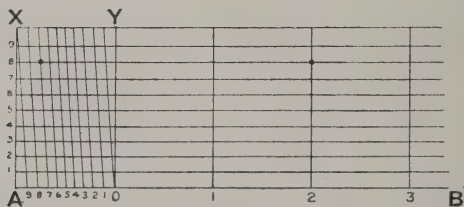


FIG. 12.

(c) Through A , 0, 1, 2, draw lines perpendicular to AB .

(d) Now divide $A0$ into 10 equal parts, and mark them as shewn in Fig. 12.

(e) Divide XY similarly.

(f) Draw diagonal lines as shewn in the diagram, joining the *first* point of subdivision of OA with the *second* point on the top parallel, and so on.

(g) Now make, on squared paper, an enlarged drawing of the scale representing $\frac{1}{10}$ " , as shewn (Fig. 13).

(h) Write answers to the following questions :

(i) What part of an inch is AN ?

(ii) What is the size of CD compared with AN ?

(iii) What part of an inch, therefore, is CD ?

(i) Write down the actual length of EF , GH , and KL .

11. Exercises in setting off Lines of Given Lengths.

(a) To set off a line 2.7 " long.

Place one point of a pair of dividers on 2 in AB (Fig. 12), and extend the dividers till the other point reaches 7 in the subdivided inch OA . The distance between the points of the dividers is then 2.7 ".

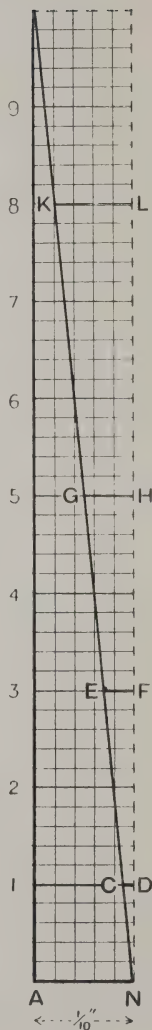


FIG. 13.

(b) To set off a line $2.78''$ long.

Proceed as in (a) for $2.7''$. Now move one point along the perpendicular marked 2 until it reaches the *eighth* parallel to AB (marked 8).

At the same time move the other point of the dividers along the *diagonal* marked 7 till it also reaches the *eighth* parallel.

The distance between the points is then $2.78''$.

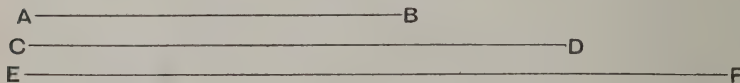


FIG. 14.

(c) Draw lines in your note-book and set off

(i) $1.8''$.

(ii) $1.93''$.

(iii) $2.14''$.

(iv) $3.06''$.

(v) $4.57''$.

(d) Using the diagonal scale you have drawn, find the lengths of the lines in inches and hundredths (Fig. 14).

12. Diagonal Scale shewing Chains and Links.

Proceeding as in Ex. 10, construct a diagonal scale shewing chains and links.

NOTE.—*This should be very carefully made, as great use will be made of it in subsequent exercises.*

13. Measurements for Field Book.

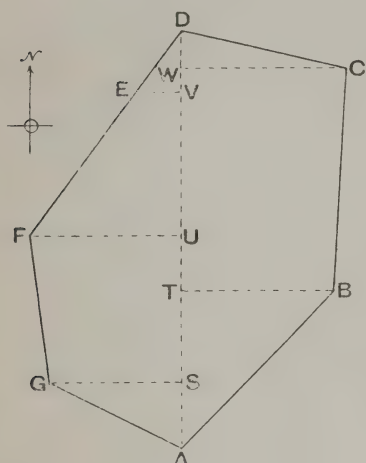


FIG. 15.

Links.		
	to <i>D</i>	
	850	
	770	336 to <i>C</i>
to <i>E</i> 90	725	
to <i>F</i> 311	436	
	320	318 to <i>B</i>
to <i>G</i> 260	140	
From	<i>A</i>	go North

- (i) Above are shewn extracts from a Field Book. They consist of a plan of an area, together with measurements arranged in a peculiar form.
- (ii) The Field Book is read *upwards*, beginning at the lowest line. In this case the chain-line *AD* runs from starting point *A*, due North.
- (iii) The centre column of the Field Book refers to measurements made *from* *A* along the chain-line to the points from which the offsets spring.
- (iv) The columns on the left and right give the lengths of the offsets to the left and right of the chain-line respectively.

14. Drawing a Plan from the Field Book.

(Using the measurements and sketch in the preceding exercise.)

(a) Construct a diagonal scale of convenient size. (NOTE.—As 850 links is the greatest dimension, a scale of 1" to 1 chain or $\frac{3}{4}$ " to 1 chain would be suitable.)

(b) Lay down the chain-line AD to represent a direction due North from A , and make $AD = 850$ links (Fig. 15).

(c) Mark off $AS = 140$ links.

(d) From S draw offset SG to the left, so that $SG = 260$ links.

(e) Obtain point T by making $AT = 320$ links.

(f) Draw TB at right angles to AD , making it 318 links.

(g) Proceed similarly, making

$$AU = 436 \text{ links.} \qquad UF = 311 \text{ links.}$$

$$AV = 725 \quad ,, \qquad VE = 90 \quad ,,$$

$$AW = 770 \quad ,, \qquad WC = 336 \quad ,,$$

(h) Complete the plan by filling in the boundary $ABCDEFGF$.

(The area of this figure will be calculated in Section II.)

15. Graph of Height.

(a) Measure your height at regular intervals, and record your results as shown by the graph.

GRAPH OF HEIGHT.

NOTE: Take Measurements to the nearest half inch.

----- *Av. Ht. of Class.*
 ———— *Own Height.*

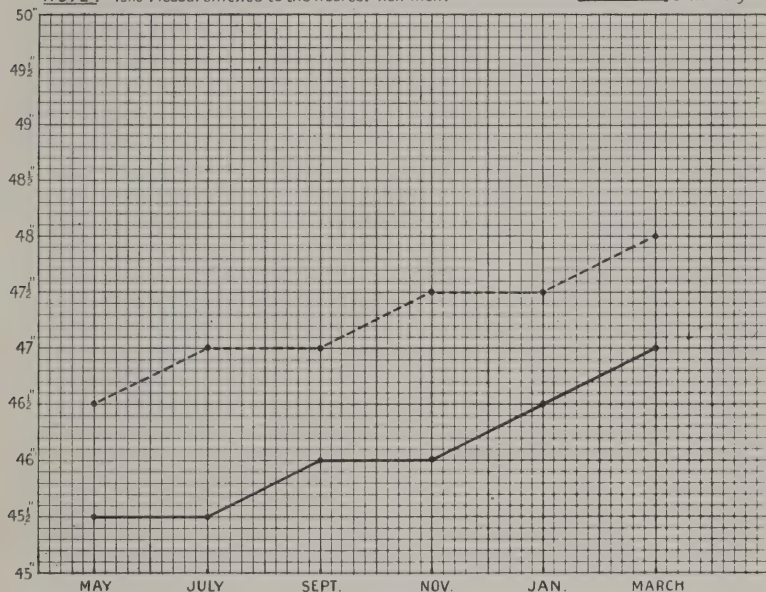


FIG. 16.

(b) Insert also the average height of the class as indicated.

(c) By how much does your height differ from the average height?

SECTION II.—AREA.

16. Finding Amount of Cloth required to bind a Book.

(a) Measure, in inches and tenths, the dimensions of the Reading Book supplied to you.

(b) Allow 1 inch all round for overlapping, and calculate the amount of cloth required to cover the book.

(c) Find the number of square yards of cloth required to cover the complete set of readers in your class.

(d) Repeat this exercise in the metric measurements, allowing 3 cms. all round for overlapping, and reducing your answer to sq. metres.

17. The Number of Tiles required to Make a Dado.

(a) With the tape measure find the perimeter of your class-room.

(b) Find the dimensions of the tile supplied to you.

(c) Calculate the number of tiles of this size that would be required to tile a dado round the room to a height of 4 ft.

18. Calculation of the Area of the Playground.

(a) Make a rough sketch of the playground in your notebooks.

(b) Measure the distances carefully with the chain, and enter each on the sketch.

(c) Calculate the area of each parallelogram or triangle separately.

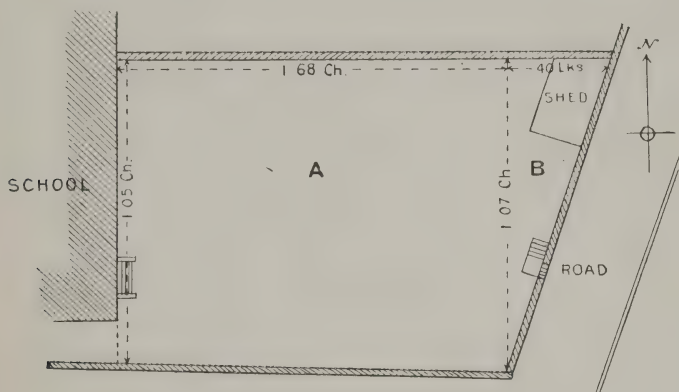


FIG. 17.

(d) Total your results, and convert the sq. chains to sq. yds.

(e) Enter the area on your sketch.

19. Plan of the Playground.

(a) From your rough sketch with its measurements, and using the diagonal scale, make a plan of the playground (Fig. 17). (Scale 3" to 1 chain.)

(b) Insert in each section its area, and place the total area below.

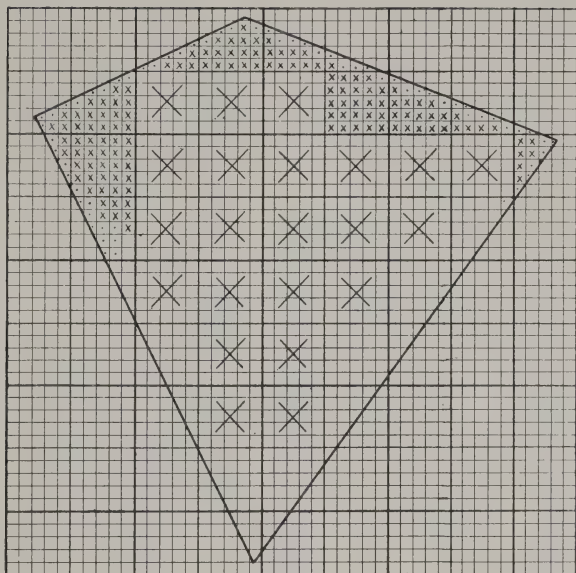


FIG. 19.

21. The Area of an Irregular Quadrilateral—By Calculation.

(a) Take the quadrilateral $ABCD$ which you constructed in Ex. 20.

(b) Measure BD , AE and CF in inches and tenths.

(c) Calculate the area of the two triangles ABD and BCD , and hence find the area of the whole figure $ABCD$.

(d) Compare your result with Ex. 20 (e), and record thus :

Area by Squared Paper (Ex. 20).	Area by Calculation (Ex. 21).	Difference.

22. Finding the Area of a Field.

(a) Walk round the field, and place poles at each of the points as at *A, B, C, D, E, F* and *G*.

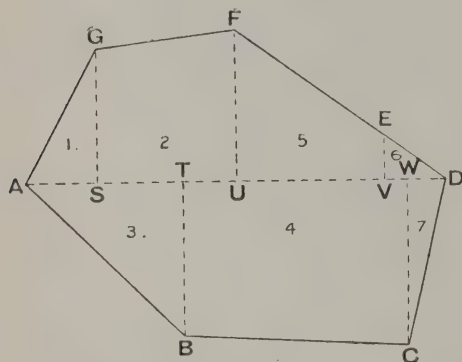


FIG. 20.

(b) Make a rough sketch of the field (Fig. 20).

(c) Start at *A*, and sight *D* with the cross-staff.

(d) When opposite *G*, i.e. at *S*, sight *G* and *D* together with your cross-staff.

(e) Measure *SG*.

(f) Repeat this at *T, U, V* and *W*, measuring each offset in turn.

(g) Calculate the areas of the figures 1 to 7 separately, and total for the complete area.

NOTE.—Arrange your Field Book as indicated in Ex. 13.

23. The Square on the Hypotenuse—Using Squared Paper.

(a) On squared paper construct a right-angled triangle, with sides containing the right angle 3" and 4" respectively.

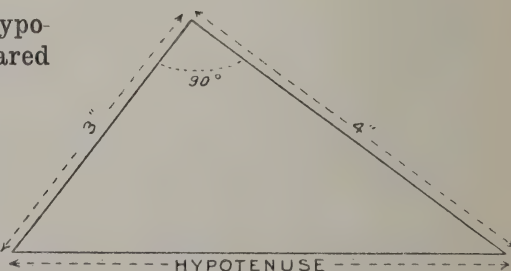


FIG. 21.

(b) Measure the hypotenuse carefully, and record its length (Fig. 21).

(c) On each side construct a square, and calculate the area of each as in Ex. 20 (Fig. 22).

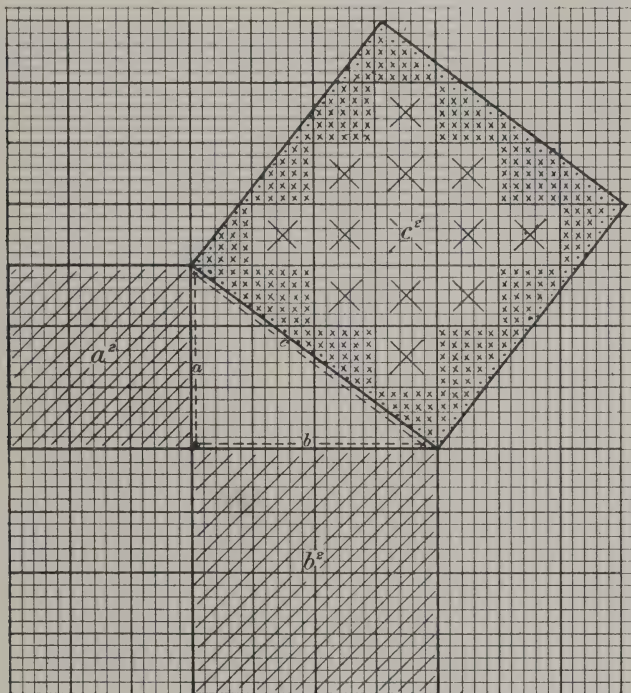


FIG. 22.

I. From Squared Paper.

Large sqs. = $13 = 3 \cdot 25$ sq. ins.

Small „ = $248 = 2 \cdot 48$ „

Part „ = $100 = \cdot 5$ „

Total = $6 \cdot 23$

II. By Calculation.

$$a^2 + b^2 = (1 \frac{1}{2})^2 + 2^2$$

$$= (\frac{3}{2})^2 + 2^2$$

$$= \frac{9}{4} + \frac{4}{1} = 6 \cdot 25 \text{ sq. ins.}$$

(d) Find the area of the sum of the squares on a and b , i.e. $a^2 + b^2$, and compare with the square on c , i.e. c^2 .

(e) Repeat the exercise twice more, using other dimensions for the sides of the right-angled triangle.

24. The Square on the Hypotenuse—By Cutting Out.

(a) Measure carefully the sides of the right-angled triangle given below (Fig. 23).

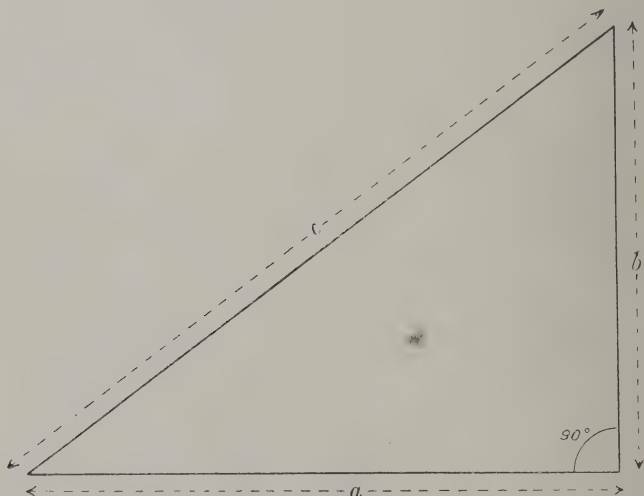


FIG. 23.

(b) On paper construct three squares with sides equal to a , b and c , placing the square of a and that of b side by side, as shewn (Fig. 24).

(c) With centre A and radius equal to c , describe an arc cutting BC in K (Fig. 25).

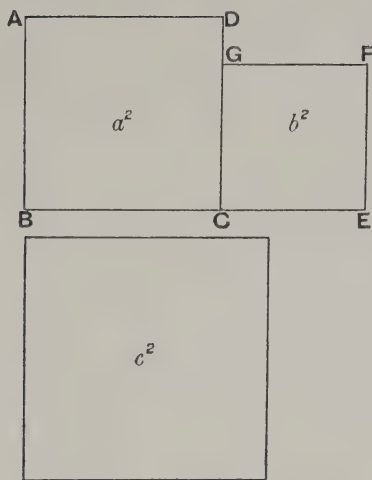


FIG. 24.

(d) Join AK and KF and shade the triangles, as shewn (Fig. 25).

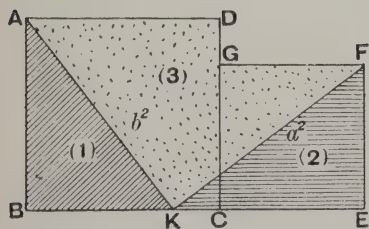


FIG. 25.

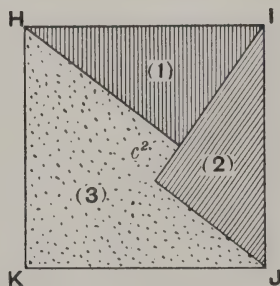


FIG. 25a.

(e) Cut out the two squares together, and then cut along the lines AK and KF (Fig. 25).

Number the pieces (1), (2) and (3).

(f) Place these pieces in position over the large square (Fig. 25a), so as to cover it exactly.

(g) Write down what you have discovered concerning the size of the square of c as compared with the squares of a and b together.

(h) From Exs. 23 and 24,

If square of c be written c^2 ,

,, ,, a ,, ,, a^2 ,

,, ,, b ,, ,, b^2 ,

write a formula to express the relation between the squares.

25. Surface of a Cylinder.

(a) Find the perimeter of the cylinder by means of the tape measure (Fig. 26).

(b) Measure its height carefully.

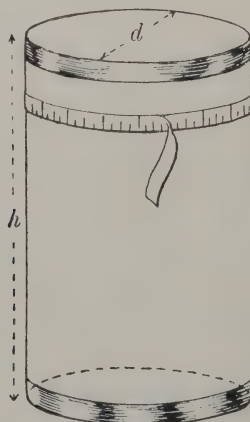


FIG. 26.

(c) From these dimensions, calculate the area of its curved surface.

(d) Now calculate the area of the circular ends.

(e) Total your results for the complete surface of the cylinder.

26. Surface of a Sphere.

NOTE.—*This exercise is to be worked after Ex. 30.*

(a) Take the hollow cylinder used in Fourth Year's Course, Ex. 30, and find the area of its curved surface.

(b) Fit into it the sphere used in Ex. 30, as shewn in Fig. 27.

(c) Compare the height (h) of the cylinder with the diameter

(d) of the sphere.

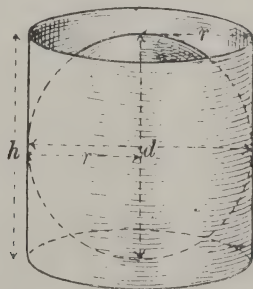


FIG. 27.

(d) Write in your note-book the statement supplied by your teacher, and from it express the area of the curved surface of the cylinder.

(e) In the same way write down the statement expressing the area of the surface of a sphere.

(f) What conclusion can you draw concerning the area of a sphere as compared with that of its circumscribing cylinder ?

27. Finding the Surface of Any Sphere.

(a) Place the sphere on a level surface.

(b) By means of two wooden blocks measure the diameter (d), as shewn in Fig. 28.

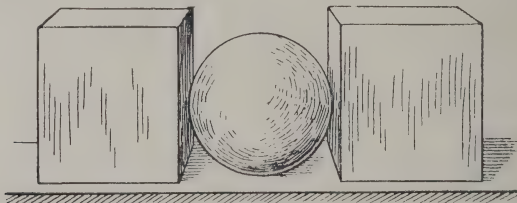


FIG. 28.

(c) Using the formula obtained in Ex. 26, find the area of the surface of the sphere.

SECTION III.—VOLUME AND CAPACITY.

28. Construction of Square Prism and Pyramid.

(a) Cut out from cardboard the square prism according to the dimensions shewn in Fig. 29.

Cut to *full* size, so that the square pyramid, when made, will fit inside it.

(b) Along the dotted lines make a *light* cut with the knife, preparatory to bending.

(c) Gum strips of binding paper on the edges, as shewn, and, when this is dry, fold the cardboard and fasten the edges.

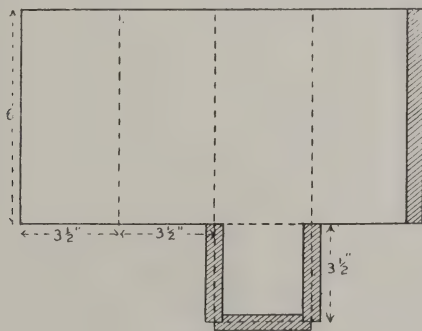


FIG. 29.

(d) Now mark out the square pyramid, as shewn in Fig. 30.

(i) Describe a circle having radius $6\frac{1}{2}$ ".

(ii) With your compasses step four distances of $3\frac{1}{2}$ " (equal to the inside measurement of your square prism).

(e) Cut out the cardboard figure, and gum a strip of binding paper along the extreme edge (from B to C , Fig. 30).

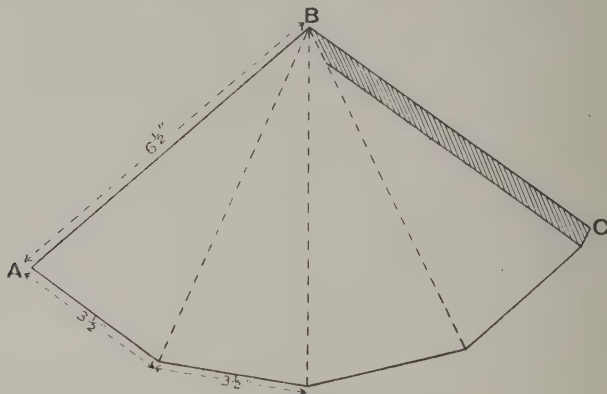


FIG. 30.

- (f) Fold the cardboard, and fasten the edges.
 (g) When dry, place the pyramid inside the square prism already made.

29. Volume of Square Prism and Pyramid.

(a) Fill the square prism (made in Ex. 28) with fine sand, and find its volume in cubic inches, using the graduated jar.

(b) From its dimensions, *calculate* its volume.

(c) Compare these two results, and, if necessary, repeat (a).

(d) When the two results are approximately equal, find their average, and enter it as a result, as shewn on page 34 (I.).

(e) Place the pyramid inside the prism (Fig. 31), and fill around it with fine sand.

Find the volume of this sand.

(f) Knowing the volume of the prism (d) and the volume *outside* the pyramid (e), calculate the volume of the pyramid itself.

(g) Now take out the pyramid; invert it and carefully fill it with fine sand.

Find its volume.

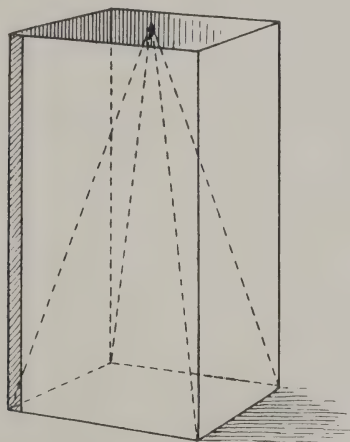


FIG. 31.

(h) Compare this result with that obtained in (f).

(i) Take the average of (f) and (g), and enter it in your table (II.).

(j) Now compare the volumes of the prism and pyramid, and calculate how many times the latter is contained in the former.

(k) Beneath your results, write briefly what you have learned regarding the volume of the square pyramid.

I. VOLUME OF SQUARE PRISM.		II. VOLUME OF SQUARE PYRAMID.		AV. VOL. OF PRISM AV. VOL. OF PYRAMID.
By Filling.	By Measurement.	By Subtraction.	By Filling.	
<i>e.g.</i> 75 cu. ins.	73½ cu. ins.	cu. ins.	cu. ins.	$\frac{\text{cu. ins.}}{\text{cu. ins.}} =$ times
Average = 74¼ cu. ins.		Average = cu. ins.		

30. Volume of the Sphere.

(a) Take a ball which is not too large to be immersed later in one of the measuring jars.

(b) Measure its diameter carefully :

(i) Using the calipers and opening them until the ball will *just* pass between the points ; or

(ii) Using two square wooden blocks (Fig. 28).

(c) Knowing the diameter of the ball, construct a cardboard cylinder which will just contain it, *i.e.* its diameter and its height will each be equal to the diameter of the ball (Fig. 32).

(d) By filling with sand, find the volume of this cylinder.

(e) *Calculate* the volume of the cylinder, and compare with the preceding result.

(f) Now fill a graduated cylinder with water to any known mark, *e.g.* 10 cu. ins.

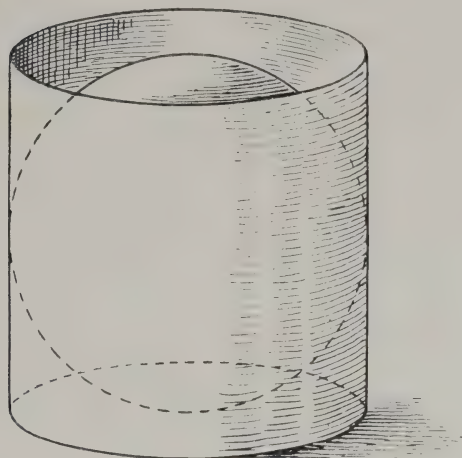


FIG. 32.

Carefully place the ball in the water and note the rise. (If the ball floats, press it below the surface with a long pin or needle.)

(g) Enter results as you proceed, and complete as shewn.

	DIAMETER OF SPHERE AND CYLINDER.	VOLUME OF CYLINDER.		VOLUME OF SPHERE.	$\frac{\text{VOL. OF SPHERE}}{\text{VOL. OF CYLINDER}}$
		By Filling.	By Calculation.	By Dis- placement.	
<i>e.g.</i>	2.3 ins.	cu. ins.	cu. ins.	cu. ins.	$\frac{\text{cu. ins.}}{\text{cu. ins.}} = \text{times}$
		Average =	cu. ins.		

(h) Now find, by division, the number of times that the volume of the sphere is contained in that of the cylinder.

(i) If the cylinder contained three units of volume, how many would the sphere contain?

(j) Complete the following statement, entering the same in your note-book:

VOLUME OF SPHERE = OF VOL. OF CONTAINING CYLINDER.

NOTE.—*After this exercise, work No. 26.*

31. Volumes of Spheres.

(a) Take another ball, and find its volume:

(i) By immersing in water.

(ii) By measuring its diameter, and then calculating, using the principle learned after working Ex. 30.

(b) Compare the two results, and, if necessary, repeat both operations till the results are approximately equal.

(c) Record your results thus:

BALL.	DIAMETER.	VOLUME.		DIFFERENCE.
		By Immersion.	By Calculation.	
e.g. 1	2 ins.	$4\frac{1}{4}$ cu. ins.	$4\frac{4}{21}$ cu. ins.	$\frac{5}{84}$ cu. ins.
2				
3				

(d) Repeat the exercise with other balls, large marbles, etc.

SECTION IV.—WEIGHT.

32. Weight and Volume.

(a) Take a gas-jar graduated in ccs. and partly fill with water. Read off the volume of water and enter in a table as given below.

(b) Obtain a small cube of wood and weigh it carefully by means of a delicate spring balance. Enter your result as before.

(c) Immerse the cube completely in the water, holding it down with a knitting needle.

(d) Note the position to which the water rises and enter the volume of the water and wood together.

(e) Calculate from (a) and (d) the volume of the wood alone.

(f) Refer to Year III., Ex. 44, for the weight of 1 cc. of water, and then find the weight of the water displaced by the cube. Record your result as before.

VOLUME.			WEIGHT.	
Water.	Water and Cube.	Cube.	Cube.	Displaced Water.

(g) Examine your tabulated results and write down what you have discovered concerning :

- (i) The *volumes* of the cube and displaced water.
- (ii) The *weights* „ „ „

33. Weight and Density.

(a) From the figures obtained in Ex. 32, calculate the weight of 1 cc. of wood and of 1 cc. of water (*i.e.* unit volume).

(b) *The weight of unit volume* (1 cc.) is known as the *Density* of a body.

34. Volume and Density.

I. Equal Volumes.

(a) Obtain *equal volumes* of wood (various kinds), soap, wax, metal, etc.

(b) Weigh each in turn, and record results.

(c) Compare their weights.

(d) Compare their volumes.

(e) Arrange them in order of density, commencing with the greatest.

II. Equal Weights.

(a) Obtain *equal weights* of stones, wood, iron, etc.

(b) By means of the graduated gas-jar, find the volume of each.

(c) Compare their weights.

(d) Find the density of each, and arrange them in order, commencing with the greatest.

(e) Write, in your own words, the method of finding the density of a substance.

35. Specific Gravity of Rectangular Solids.

NOTE.—When the densities of substances are compared with the density of water the result is known as

RELATIVE DENSITY or SPECIFIC GRAVITY.

Specific Gravity (s.g.), therefore, is the weight of a body compared with the weight of an equal volume of water.

(a) Take a rectangular piece of wood, and find its weight in grams.

(b) Measure it up and calculate its volume in ccs.

(c) What is the weight of 1 cc. of water ?

(d) What is the weight of a volume of water equal to the volume of the wood ?

(e) Enter your results as shewn below, and calculate the specific gravity of the wood.

Solid.	Weight.	Volume.	Weight of Equal Volume. of Water.	$\frac{\text{Weight of Solid}}{\text{Weight of Equal Vol. of Water}} = \text{Specific Gravity.}$
g. Wood (oak)	30 grams	36 ccs.	36 grams	$\frac{30}{36} = \frac{5}{6} = .83$

(f) Repeat the experiment, using other solids such as marble, glass, iron, lead, etc., and enter results in the above table.

(g) Write in your own words, the method and formula for finding the specific gravity of a solid.

36. Specific Gravity of Solids by Immersion.

(a) Take a measuring jar graduated in ccs. and about half fill it with water.

(b) Note the number of ccs. of water in the jar.

(c) Take a stone, and find its weight in grams.

(d) Completely immerse the stone in the water contained in the measuring-jar.

(e) Note the height of the water in the jar now.

(f) From this calculate the volume of the stone.

(g) What will be the weight of a volume of water equal to the volume of the stone ?

(h) Enter results, and calculate the specific gravity of the stone.

	SOLID.	WEIGHT.	CCS. OF WATER IN JAR.		VOLUME OF STONE.	WEIGHT OF EQUAL VOLUME OF WATER.	SPECIFIC GRAVITY.
			At first.	After im- mersion.			
<i>e.g.</i>	Stone	45 grams	10 ccs.	24 ccs.	14 ccs.	14 grams	$\frac{45}{14} = 3.2$

(i) Repeat the experiment with other bodies, and add to your results.

37. Graph of Weight.

(a) Take your weight in stones and lbs. at regular intervals, and record on the graph.

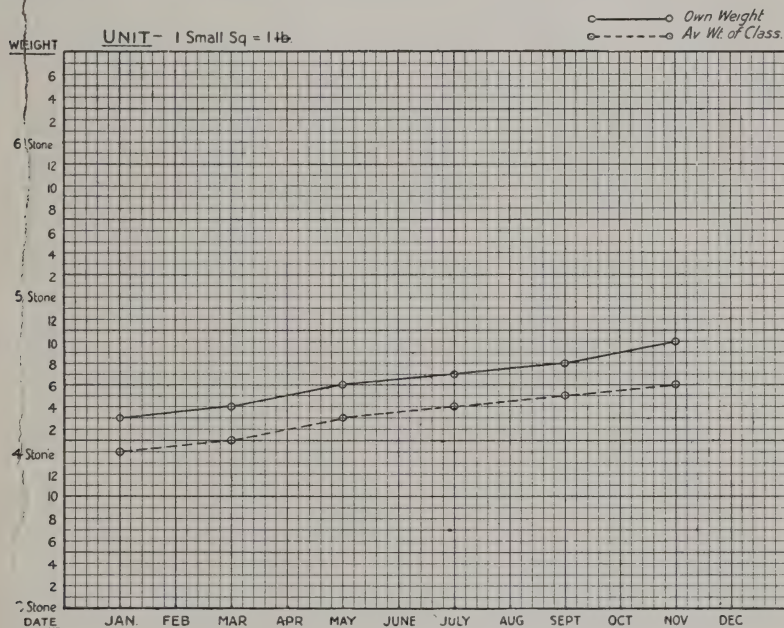


FIG. 33.

(b) Insert the graph shewing the average weight of the class.

(c) By how much does your weight differ from the average weight?

SECTION V.—TIME.

38. Obtaining North and South Line.

(a) Erect a pole in the playground where the sun can shine on it at 9 a.m.

(b) Mark the direction of the shadow and also its length.

(c) At the base of the pole attach a string, making it the same length as the shadow cast.

(d) With the help of the string chalk a circle on the playground.

(e) Make another observation in the afternoon a few minutes before 3 p.m., and mark the spot where the shadow meets the arc. Draw a line from this point to the foot of the pole.

(f) Bisect the angle between the two shadow lines.
This line will run true North and South.

39. Altitude of Sun at Noon.

(a) Erect a small rod on a board or slab of wood (Fig. 34).

(b) Draw a line on the wooden base, passing through the spot where the rod is fixed.

(c) Place the apparatus perfectly horizontal in the sunshine, so that the drawn line lies exactly north and south.

(d) When the shadow of the rod falls along the line on the board, mark the length of the shadow.

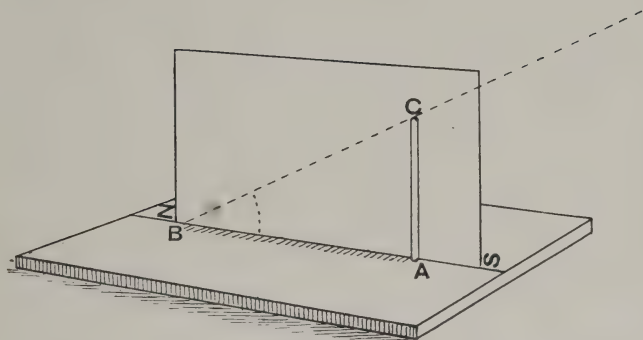


FIG. 34.

(e) Now hold a piece of paper vertically on the north and south line, and mark the three points *A*, *B* and *C*.

(f) The angle ABC records the altitude of the sun at noon for the day.

(g) Measure the angle with your protractor, and enter your result.

40. Construction of Sun-dial.

(a) Take a slab of wood about 1 ft. square, and upon it paste a circular piece of stout paper (diameter about 10").

(b) Draw the diameter of the circle, and place the slab absolutely level so that this diameter is due north and south (Fig. 35).

(c) Fix a knitting-needle at the centre of the circle, and incline it towards the north at an angle equal to the latitude of your town.

(d) At each hour of the day mark the spot on the circle where the shadow of the knitting-needle crosses it.

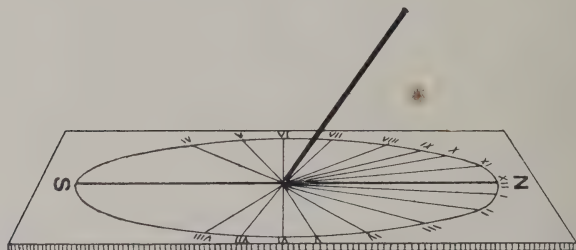


FIG. 35.

(e) Join these marks to the centre, and against each, place in Roman numerals the hour when taken.

(f) Make further observations, and so mark off each space into quarter-hours.

41. To calculate Rate of Motion—Distance known.

(a) From the marked line set off a distance of 55 yds. by means of the chain.

(b) At this distance draw a line parallel to the starting line.

(c) Working in groups, step off together at the word of command, and walk the distance of 55 yds. as evenly as you can.

(d) By means of the stop-watch your time taken in walking this distance will be found.

(e) Make columns as shewn below, and enter results.

Group	METHOD.	DISTANCE.		TIME TAKEN.	RATE OF MOTION. (Mls. per hr.)
		Yards.	Ml.		
A	By walking	55 yds. = $\frac{1}{32}$ ml.		secs.	
B					
C					
D					
E					
AVERAGE RATE OF MOTION =					

(f) From your results, *calculate* your rate of motion in miles per hour.

(g) Now obtain the times taken by the other groups of scholars.

(h) Enter all results; calculate rates of motion, and find the average rate of motion.

47

2. To calculate Rate of Motion—Time known.

(a) From the marked line, step off together at the word of command, and *halt* when directed.

(b) Record the time taken (as given to you) in walking this distance.

(c) By means of the chain, find the distance you have walked.

(d) Enter results in a table, as shewn on page 46, and calculate your rate of motion in miles per hour.

Group	METHOD.	TIME TAKEN.	DISTANCE.		RATE OF MOTION. (Mls. per hr.)
			Chains.	Yards.	
<i>C</i> <i>D</i> <i>E</i> <i>A</i> <i>B</i>	By walking	20 secs.		=	
AVERAGE RATE OF MOTION =					

(e) Enter results of the other groups, and work out average for the class.

43. Horizontal Angles.

(a) Measure with your protractor the size of the angles shewn in Fig. 36. State how many degrees each one is greater or less than a right angle.

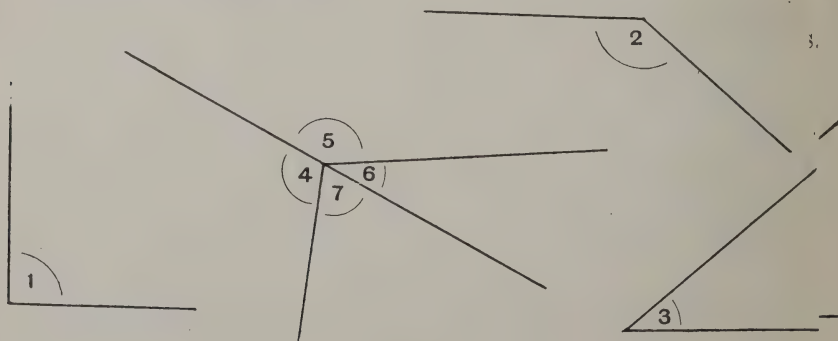


FIG. 36.

(b) Find the total of angles 4, 5, 6 and 7, and calculate the number of right angles to which these are equal.

(c) Write down a statement regarding the total size of any number of angles meeting at a point.

44.

Vertical Angles.—Altitude.

(a) Fix the Theodolite firmly with its circular base perfectly horizontal. A spirit-level should be used for this purpose.

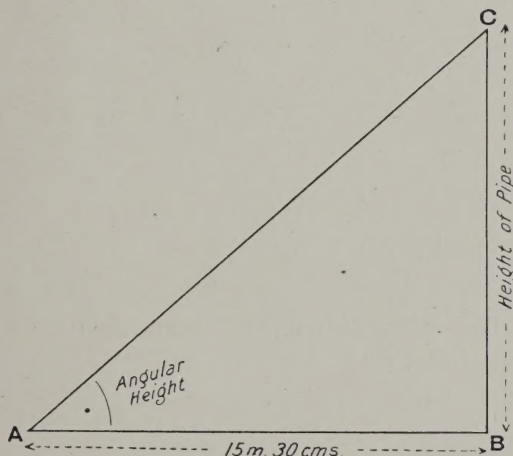


FIG. 37.

(b) Each boy will take his turn in sighting an object such as the top of a flagpole, window, water-pipe, etc., after which he will record the angular height in his notebook.

(c) Measure the distance from the centre of the base of the Theodolite to the foot of the object and record.

(d) Lay down this distance to scale (AB), and plot the size of the angle BAC .

(e) From the point B erect a perpendicular to meet in C .

(f) Measure BC with care, and calculate therefrom actual height of the pipe.

45. Horizontal and Vertical Angles—Altitude and Azimuth. 1 to fix the position of a Star.

NOTE.—*This exercise should be worked whenever a planet or the moon is visible during school hours.*

(a) Erect the Theodolite as before, so that the zero mark points directly to the south.

(b) Swing the sighting tube round until it points towards an imaginary vertical line joining the star with the horizon.

(c) Read off the horizontal angle through which the indicator has travelled from the south point, and record in your notebook.

(d) Now incline the tube until the star is seen to coincide with the cross wires, and read off the vertical angle through which the tube has been raised.

This is known as the ALTITUDE of the star.

The horizontal angular distance from the south point called the AZIMUTH of the star.

(e) Readings should be taken on several days and the results compared.

(f) What conclusion can you draw from them?

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BELL'S OUTDOOR AND INDOOR EXPERIMENTAL A



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